Rise of the Planet of the Apps: A Systematic Study of the Mobile App Ecosystem

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ABSTRACT

Mobile applications (apps) have been gaining rising popularity due to the advances in mobile technologies and the large increase in the number of mobile users. Consequently, several app distribution platforms, which provide a new way for developing, downloading, and updating software applications in modern mobile devices, have recently emerged. To better understand the download patterns, popularity trends, and development strategies in this rapidly evolving mobile app ecosystem, we systematically monitored and analyzed four popular third-party Android app marketplaces. Our study focuses on measuring, analyzing, and modeling the app popularity distribution, and explores how pricing and revenue strategies affect app popularity and developers' income.

Our results indicate that unlike web and peer-to-peer file sharing workloads, the app popularity distribution deviates from commonly observed Zipf-like models. We verify that these deviations can be mainly attributed to a new download pattern, to which we refer as the *clustering effect*. We validate the existence of this effect by revealing a strong temporal affinity of user downloads to app categories. Based on these observations, we propose a new formal clustering model for the distribution of app downloads, and demonstrate that it closely fits measured data. Moreover, we observe that paid apps follow a different popularity distribution than free apps, and show how free apps with an ad-based revenue strategy may result in higher financial benefits than paid apps. We believe that this study can be useful to appstore designers for improving content delivery and recommendation systems, as well as to app developers for selecting proper pricing policies to increase their income.

Categories and Subject Descriptors

D.4.8 [**Operating Systems**]: Performance—*Measurements; Modeling and prediction; Simulation*

Keywords

Appstores; Mobile Apps; Workload Characterization; App Popularity; Clustering effect; App Pricing; Revenue

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IMC'13, October 23–25, 2013, Barcelona, Spain.
Copyright 2013 ACM 978-1-4503-1953-9/13/10 ...$15.00.
http://dx.doi.org/10.1145/2504730.2504749.

1. INTRODUCTION

With more than 640 million active mobile devices as of July 2012 [9], the market of mobile devices is one of the fastest growing. Along with this growth, recent advances in mobile technologies facilitated a plethora of *mobile applications (apps)*; for example, the Android Market experienced a sevenfold increase in the number of offered apps from 100,000 to 700,000 within the last two years [8]. Typically, apps are hosted and distributed to end users through an increasing number of *mobile application stores (appstores)*. Appstores provide a new way of developing, downloading, and updating software applications for mobile devices, and create new business opportunities for application developers.

Despite this rapid evolution, there have been only a few large-scale studies of mobile appstores, mostly focusing on security and privacy aspects of mobile apps [32, 33, 44, 45]. However, appstores provide essentially a public marketplace matching mobile users and developers, and hence can offer valuable insights across a diverse set of dimensions ranging from app download patterns and popularity trends, to developers' revenue strategies. To this end, through a study of four popular third-party Android appstores over several months, our work aims to better understand appstore properties by focusing on two main aspects:

- *Q1:* How can we characterize the popularity of different mobile applications?
- *Q2:* What are the pricing and revenue strategies followed by app developers?

To examine *Q1*, we first characterize the app popularity distribution. Our results highlight a typical "Pareto effect," with 10% of the apps accounting for 70–90% of the total downloads. While such phenomena have also been observed in the popularity of web objects [25] and video content [21], the app popularity distribution appears truncated at both head and tail, and this observation is consistent across all examined appstores. Our analysis shows that truncation at the head of the distribution is caused by the "fetch-at-most-once" property, also found in peer-to-peer file sharing systems [34]. Contrary, we attribute tail truncation to a phenomenon we refer to as the "clustering effect," which captures the tendency of users to show a strong temporal affinity to app categories, by selectively downloading apps from certain categories over time. These insights lead us to propose a new model to approximate the popularity distributions observed in appstores, and through simulation results we show that it closely captures the observed behaviors.

Typically, appstores offer two categories of mobile apps: paid and free. In *Q2*, we examine whether offering a paid or free ad-based app is a better revenue-making strategy for developers. To this end, we first study the differences between paid and free apps.